

SYNTHESIS CHARACTERIZATION AND MECHANICAL BEHAVIOR OF RICE HUSK ASH REINFORCED AL-20MG 10 CU ALLOY MATRIX HYBRID COMPOSITES

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ABSTRACT

The aim of this work is to fabricate hybrid composites by using Rice husk ash (RHA), an agro waste as reinforcement to AL-20MG-10CU high strength alloy. Rice husk ash particles of 3, 6, 9 & 12 % by weight were used, to develop metal matrix composites, using a liquid metallurgy route. The microscopic structural studies have been carried out using scanning electron microscope, to analyze the distribution of RHA particles. The usage of any metal matrix composites always depends upon the strong wettability of reinforcement particles in a matrix. For the strong wettability, uniform distribution of particles and good disposability stir casting method is considered, for the development of composites. The physical and mechanical behavior of the material was determined through density, hardness, tensile strength, impact energy calculations. The results revealed that, abundant rice husk can be used in the production of metal matrix composites for engineering applications.

KEYWORDS: AL-20MG-10CU, RHA, stir casting, density mechanical properties & FESEM

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INTRODUCTION

BACKGROUND INFORMATION

Many researchers in the present world have been looking for the maximum optimization in the development of new material. The development of low-cost hybrid composites, which contains eco-friendly reinforcement material, has been one of the major innovations in the field of material science [1].

This work focused on the development of hybrid composites with high performance indices, at a reduced cost. The well confessed good performance in practical application and consequent high demand for a hybrid composite is attributed to its excellent properties such as high specific strength and stiffness, a low thermal coefficient of expansion, wear and tear and corrosion resistance among others [2]. These property combinations are very useful, for various industrial applications.

The development of composites using recycles agro wastes as reinforcing fillers, is the most opted research work for many research by considering environment [3].

The high strength Al-Mg-Cu alloys exhibit progressive changes in automobile and aero space industries. With an increase in demand for low weight, advanced design concepts and new manufacturing methods, with sudden changes in dimensions, configurations and loads of industrial components engineers choose high strength alloys, which is a substitute to conventional alloys [4,5,6]. Burning of agro-wastes such as baggase, rice husk,

coconut shell, bamboo leaf and ground nut shell as particulates reinforcement for the development of high strength alloys is the only low-cost option for researches to develop a material with specific properties. Rice Husk Ash (RHA) is an agriculture waste by-product which is abundantly available. During milling of paddy, about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as a husk. About 72 % of organic volatile matter contains in rice husk and the remaining 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). For every 100 kgs of paddy milled, about 22 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 25% of RHA is generated. It is estimated that about 60-70 million tons of RHA are produced annually worldwide [7]. In the present study, the fabrication characteristics and mechanical behavior of Al-20Mg-10Cu alloy matrix hybrid composites are developed by using rice husk ash (RHA) as reinforcement at different weight fractions

S. D. Saravanan [7] et.al fabricated Rice Husk Ash Reinforced Aluminum alloy Matrix Composites and investigated the mechanical properties. There is an increment in the Tensile Strength, Compression Strength and Hardness increases with the increase in the weight fraction and the ductility of the composite gets decrease due to increase in hardness and clustering of particulates

Victor Sunday Aigbodion [8] et.al, fabricated Al-Si-Fe/Rice husk ash particulate composite synthesis, by double stir casting method and investigated the mechanical properties. There is an increase in the yield strength, ultimate tensile strength and hardness values increase up 15% rice husk ash addition. However, it is accompanied by a general reduction in impact energy and density. For optimum service performances of this alloy, rice husk ash addition should be between 10-15% and not exceed 15% in order to develop better necessary properties.

MATERIAL AND EXPERIMENTATION

Rice husk is procured from local sources in India. Then it was washed with distilled water to remove the dust particles and dried in sunny atmosphere for 1 day. Washed rice husk is then heated to 150°C for 2 hr duration to remove the moisture and organic matter. During this operation, the color of the husk is changed from yellowish to black because of removal of organic matter. It is then heated to 500°C for 12 h to remove the carbonaceous material. After this operation, once again the color is changed from black to grayish white. The obtained RHA is used as a reinforcement material for the preparation of composites [9]. The chemical composition of the rice husk ash after the above treatments is given in Table 1.

Table1: Rice Husk Ash Composition

Constituent	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	LOI
%	94.04	0.249	0.136	0.622	0.442	0.023	2.49	3.52

Alloy Preparation

The synthesis of the metal matrix composite that was used in this study was produced using double stir-casting method [10]. Commercial pure aluminum (99.5+ % EC grade) was procured from M/s HINDALCO as 20 kg ingots, bus-bars of conductivity grade copper (99.95% Cu) and high purity magnesium ingot (99.9%) are purchased M/S EXCLUSIVE MAGNESIUM from the local market.

Cut ingots of pure aluminum were melted in electric heating resistance furnace in clay graphite crucible at 730°C. In order to prevent excessive oxidation of the metal Coverall (0.1 wt. % of metal) proprietary covering agent is used.

Copper pieces wrapped in aluminum foil were added to the aluminum melt at 800°C and the same temperature was maintained till copper completely melts. Magnesium in the form of thin slices wrapped with aluminum foil was added to the Al-Cu alloy melt after the furnace temperature was reduced to 750°C. Magnesium oxidation was minimized by plunging the slices in to the bottom of the melt and allowed to melt then itself. The melt was well mixed with a double stirrer for uniformity in the composition a small amount of Coverall was once again added to the melt. The furnace temperature cooled down just below the liquid us at 500⁰ c to keep the slurry in a semisolid state. The preheated rice husk ash particles were added to the slurry and mixed manually by using grates. After sufficient manual mixing was done, the composite slurry was re-heated (700⁰c) to a fully liquid state and then automatic mechanical mixing was carried out for about 20 minutes at an average stirring rate of 150 rpm. The temperature of the furnace was gradually reduced to intervals of 450⁰c The top layer was skimmed and metal was cast into 120 mm x 10 mm cylindrical finger molds[11].

Specimen Preparation

The above experimentation procedure is repeated for different weight fractions of 3%, 6%, 9% and 12 % RHA particle reinforced in Al – 20Cu-10 cu alloy and their sample designations shown in table-2

Table.2: Sample Designation of Casted Specimens

S. No	Material
1	Al – 20Cu-10 cu alloy+3% of RHA
2	Al – 20Cu-10 cu alloy+6% of RHA
3	Al – 20Cu-10 cu alloy+9% of RHA
4	Al – 20Cu-10 cu alloy+12% of RHA

Micro Structural Examination

For studies of Micro structural characterization samples of 1 cm diameter and 1cm length taken from the middle of the ingot. The samples are polished Particle distribution and presence of elements was examined using Field Emission Scanning Electron Microscope (FESEM) [12]. The samples were polished using an automatic polisher (Tegramin – 25, Struers, Denmark), to produce a mirror-like surface. Particle distribution and presence of elements were examined using Field Emission Scanning Electron Microscope (FESEM), attached with EDS (TESCAN-MIRA 3 LMH, 2014 coupled with QUANTAX 200 with XFlash BRUKER, 2014).

Density Measurement

The density of the cast specimens is determined by using Archemedies principle. Cut samples from the middle of cast specimens are immersed in distilled water and increase in volume percentage of the distilled water has been observed.

Mechanical Properties Evaluation

Mechanical Properties of the composite with different weight fractions of reinforcements were evaluated in terms of Hardness Tensile, impact and flexural properties. The samples are prepared as per ASTM standards. The results were measured by taking an average of 4 readings. The readings for each composition were noted. The readings for each composition were noted. Macro hardness was evaluated for a load of 20 kgs, with a load period of 20 sec using Vickers hardness machine. The hardness values were measured by taking an average of 3 readings. Tensile test was done as per ASTM B 557 standard on universal testing machine, with a load 80 KN. Three readings for each composition were noted for tensile and impact testing.

RESULTS AND DISCUSSIONS

Micro Structural Calculations

The microstructure of the rice husk ash reinforced alloy composite is shown in Fig. 1. The microstructure reveals that there are small discontinuities and a uniform distribution of rice husk ash and alloy particulates in the matrix region. However, there is an agglomeration and segregation of rice husk ash particles in the micro scale with alloy reinforced with 9 wt% rice husk ash particle. It is observed that the RHA particulates are visible and a good dispersion of the particulates in the alloy matrix is evident. It is also observed from Fig. 1 that there is a high volume percent of particulates dispersed in the alloy matrix. The representative EDS profiles of the 9% RHA reinforced hybrid composites are presented in Figure. 2 and confirms that the reinforcing particulates are dispersed in the high strength matrix [13].

The EDS profiles (Figure. 2) show peaks of aluminum (Al), carbon (Cu), silicon (Si), and traces of zinc (Zn). The presence of Si confirms the presence of RHA particulates

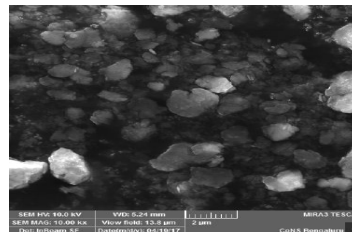


Figure 1: FESEM Images of 9% RHA Reinforced Al-20Mg 10 Cu Alloy Matrix Hybrid Composites

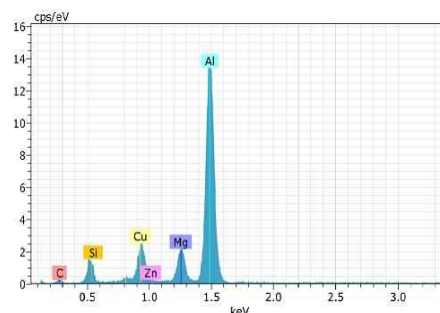


Figure 2: EDXX Analysis of 9% RHA Reinforced Al-20Mg 10 Cu Alloy Matrix Hybrid Composites

Density Results

The density results of rice husk ash reinforced alloy at different weight fractions shown in figure.3. The results reveal that 3%RHA reinforced alloy has maximum density of 2.89 g/cm^3 and 12 % RHA reinforced alloy has less density 2.52 g/cm^3 from the figure3. it can be observed that with an increase in percentage of reinforcement of RHA (i.e decrease in % of alloy) density of the composite decrease. Hence, not much change was observed in composites with an addition of RHA. The development of any hybrid composite depends on the wettability of reinforcement and matrix [14].

With an increase in wettability, there is less chance of porosity leads to increase the density of composites. Here the density of composites decreases due to increase porosity [15]

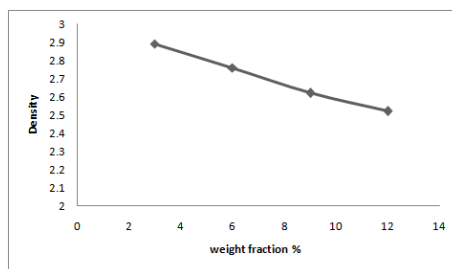


Figure 3: Variation of Density with Wt% of Nickel Coated High Strength Reinforcement

Mechanical Properties

Hardness

The hardness values for different samples were shown in [fig 4]. The hardness of Sample 3% RHA is 78.24 VHN and Sample 12% of RHA 89.98 H. V From the graph [figure 4].

It can be seen that the hardness values are increased with increase in percentage of reinforcement. The observed increased hardness two reasons one the uniform distribution of reinforced particles that can increase strengthening mechanism and the other is due the differences in coefficient of thermal expansion (CTE) between reinforcing particles and metal matrix result to elastic and plastic incompatibility. There is little increment of hardness between 9 % and 12 % weight fractions of RHA further increase in weight fraction possibility of decrease in hardness [16].

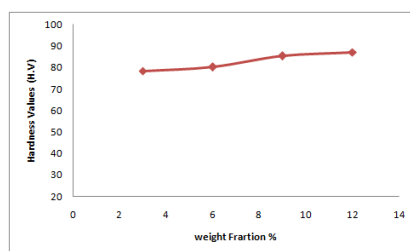


Figure 4: Variation of Hardness with Wt% of Rice Husk Ash Reinforced Hybrid Composites

Tensile Behavior

The tensile strength of casted Sample with 3 % RHA is 179.24MPa while for 12% reinforcement it was 186.64 MPa [19]. It is clear from the figure 5 that, tensile strength of composites increases with increase in weight fraction. The improvement in tensile strength of the composite is attributed to the fact that, the filler rice husk ash possesses higher resistance to loads and strong strengthening capacity of load transfer, from matrix to reinforcements. With 9% RHA the tensile strength is 186.29 MPa. There is no increase beyond 9% RHA and further increase in reinforcement there is the possibility of decrease in tensile strength, and with an Increase in RHA powder content, there is possibility of agglomerations or poor wettability of the reinforcement [17]

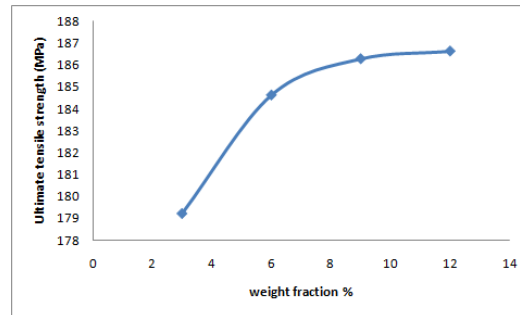


Figure 5: Effect of Rice Husk Ash Reinforced AL-10CU-20MG Alloy on Ultimate Tensile Strength

Ductility

The ductility is found to be decreased with an increase in percentage of reinforcement from figure 6. Thus, ductility of the composites is highly dependent on the weight fraction % of the reinforcement. Sample of 3% RHA exhibits maximum percentage of ductility [10.91 %] and 12 % of ductility. With increase in weight fraction the hardness of composites or clusters of RHA particles inside the matrix increase cause decrease in ductility [18]

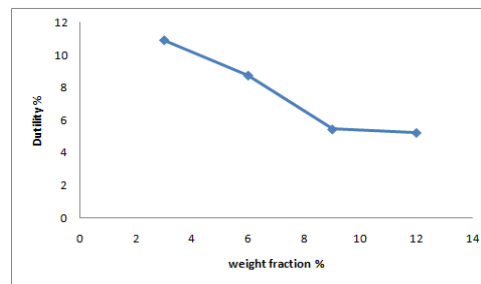


Figure .6: Effect of Rice Husk Ash Reinforced AL-10CU-20MG Alloy on Ductility

Yield Strength

The tensile strength of casted Sample with 3 % RHA is 93.75 MPa while for 12% reinforcement it was 99.38MPa. It is clear from the figure 7 that yield strength of composites increases with an increase in weight fraction. For sample with 9% RHA the tensile strength is 99.14 MPa similar to earlier results, there is no increment after 9 % reinforcement [19]

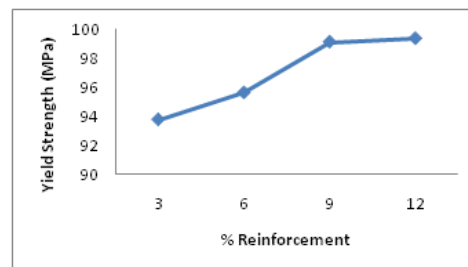


Figure .7: Effect of Rice Husk Ash Reinforced AL-10CU-20MG Alloy on Yield Strength

Impact Strength

For the composite material with 3 % RHA exhibits maximum Impact energy of 18.64 joules while 12% Rha Reinforced composites has less amount of impact energy of 11.14 joules.

The impact energy (Fig. 8) decreased as the percent rice husk ash addition increased in the alloy matrix. The brittle nature of the reinforcing materials rice husk ash plays a key role in degrading the impact energy of the composite, the alloy with 3% rice husk ash particles have the highest impact energy which means it is the toughest of them all[20].

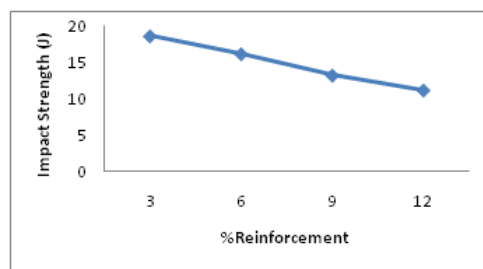


Figure 8: Variation of Impact Strength with Wt% of Nickel Coated High Strength Reinforcement

CONCLUSIONS

Rice Husk Ash, the agricultural waste can be successfully used as a reinforcing material to produce hybrid or Metal-Matrix Composite. Fabrication of hybrid composites by varying the weight fraction of RHA was successful. By FESEM analysis, there is a uniform distribution of RHA particles in alloy matrix. The density, hardness, tensile behavior, ductility and impact were evaluated. With an increase in weight fractions of RHA the density, impact energy and ductility of composites decrease, whereas ultimate tensile strength, yield strength and hardness increase due to good dispersability of RHA particles in an alloy matrix. However, composites with more than 9% weight fraction of rice husk ash particles, there was no enhancement in mechanical properties.

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REFERENCES

1. Recent advances in metal matrix composites, *Journal of Materials Processing Technology*, 53(1), pp. 273–284.
2. Robert M. Jones, *Mechanics of composite Materials*, Second Edition, 1999, p.(2).
3. Surappa, M. K. (2003), *Aluminium matrix composites: Challenges and opportunities*, *Sadhana*, 28(1), pp. 319–334.
4. Daniel B. Miracle and Steven L. Donaldson, *Miracle and S. L. Donaldson, Air force research laboratory*, pp. (1-2).
5. Dhruv Vyas, Chetna M. Vyas & Jayeshkumar Pitroda, *Utilization of Barley Husk Ash in Clay Bricks in Aspect of Indian Context: A Literature Review*, *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)*, Volume 4, Issue 1, January - February 2014, pp. 61-68
6. Ever J. Barbero, *Introduction to composite materials design*, second Edition 2011, p. (37).
7. Rohatgi. P. *Cast aluminum-matrix composites for automotive applications*, *JOM Journal of the Minerals, Metals and Materials Society*, 43(4), pp. 10–15.

8. B. Damodhara Reddy, S. Aruna Jyothy & I. V. Ramana Reddy, *Effect of Rice Husk Ash on the Properties of Ordinary Portland Cement and Portland Slag Cement with and without Superplasticizers*, *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)*, Volume 3, Issue 2, May - June 2013, pp. 1-8
9. S. D. Saravanana, M. Senthil Kumarb, *Effect of Mechanical Properties on Rice Husk Ash Reinforced Aluminum alloy (AlSi10Mg) Matrix Composites* *International Conference On design and manufacturing, Procedia Engineering* 64 (2013) 1505 – 1513
10. Victor Sunday Aigbodion, *Development of Al-Si-Fe/Rice husk ash particulate composites synthesis by double stir casting method*, *Usak University Journal of Material Sciences*, 2012, p.(187 – 197)
11. Das. S., Dan. T. K. Prasad and Rohatgi, P. K. (1986), *Aluminium alloy—rice husk ash particle composites*, *Journal of Materials Science Letters*, 5(5), pp. 562–564.
12. M. M. Siva et al., *Effect of Microstructure and Hardness Properties of Al2011 based Composites for Titanium Di Boride using Stir Casting Method*, *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)*, Volume 7, Issue 2, March - April 2017, pp. 187-200
13. K. K. Alaneme and I. B. Akintunde *Fabrication characteristics and mechanical behaviour of rice husk ash – alumina reinforced Al-Mg-Si alloy matrix hybrid composites*, *J. Mater. Res. Technol.*, 2 (1) (2013), pp. 60-67
14. Rattanasak. U, Chindaprasirt. P, and Suwanvitaya. P, “Development of high volume rice husk ash alumino silicate composites,” *International Journal of Minerals, Metallurgy, and Materials*, 17(5), pp. 654–659.
15. Kenneth Kanayo Alaneme and Kazeem Oladiti Sanusi, *Micro structural characteristics, mechanical and wear behaviour of aluminium matrix hybrid composites reinforced with alumina, rice husk ash and graphite*, Volume 18, Issue 3, September 2015, Pages 416-422
16. M. K. Surappa, *Synthesis of fly ash particle reinforced A356 Al composites and their characterization*, *Materials Science and Engineering*, vol. 480, pp. 117-124, 2008.
17. Chandrasekhar. S., Satyanarayana. K. G. Pramada and Gupta. T. N. (2003), *Review processing, properties and applications of reactive silica from rice husk - an overview*, *Journal of Materials Science*, 38(15), pp. 3159–3168
18. J. Narciso, A. Alonso, A. Pamies, C. G. Cordovilla and E. Louis, *Wettability of binary and ternary alloys of the system Al-Si-Mg with SiC particulates*, *Scripta Metall*, vol. 31, (1994), pp. 1495-1500
19. Della, V. P., Kühn, I., and Hotza, D., *Rice husk ash as an alternate source for active silica production*, *Materials Letters*, 57(4), pp. 818–821.
20. Aigbodion VS, Hassan SB, Dauda ET, Mohammed RA, *Experimental study of ageing behaviour of Al-Cu-Mg/bagasse ash particulate composites*, *Tribology in industry*. 2011 , PP.(28-35)
21. Prasad SD, Krishna RA., *Production and mechanical properties of A356.2/RHA composites*, *IJAST*. 2011; 33:518.
22. P. S. V. R. Subrahmanyam I, G. Narsaraju and B. Srinivasa Rao, *Effect of Rice Husk ash and Fly ash Reinforcements on Microstructure and Mechanical properties of Aluminium alloy (AlSi10Mg) Matrix Composites*, *International Journal of Advanced Science and Technology*, Vol.76 (2015), pp.1-8.
23. N. Chawala and Y. Shen, *Mechanical Behavior of particle reinforced metal matrix composites*, *Adanced engineering materials* 2001, pp.357-370.